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AQUATIC PLANT CONTROL WITH DIQUAT, FENAC, AND SIMAZINE IN ONTARIO FARM PONDS

THE ONTARIO WATER RESOURCES COMMISSION

AQUATIC PLANT CONTROL WITH DIQUAT, FENAC, AND SIMAZINE IN ONTARIO FARM PONDS

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SUMMARY

Diquat provided more immediate and permanent control in partial treatment plots at 2 gallons per acre than at half this rate. In several total volume treatments the permanency of control was varied. Stonewort, _Chara_ sp., was unaffected in all diquat treatments. With one exception, no curtailment of phytoplankton development was observed in several ponds following treatment with this herbicide. Determinations of diquat residues in pond water indicated a rapid disappearance of the herbicide from the water.

In total volume treatments during 1966, fenac controlled several species of aquatic plants including _Chara_ sp., at rates of 2 and 3 ppm. The following year, the results were inconclusive owing to a combination of lower application rates and unusually heavy rainfall. In all treatments fenac had no apparent effect on filamentous algae. Phytoplankton numbers were reduced in some ponds following treatment with fenac and were unaffected in others. Total recovery of phytoplankton was generally evident within 6 to 10 weeks after application of the herbicide.

In two drawdown trials, fenac failed to control sago pondweed, _Potamogeton pectinatus_ and _Chara_ sp., when applied at a rate of 15 lbs per acre, but provided seasonal control of the aforementioned species at a rate of 20 lbs per acre.

Simazine controlled filamentous algae at a rate of 0.5 ppm in three runoff ponds for the entire season. Regrowth was evident after six weeks in a stream-fed pond. Filamentous algae and submerged vascular plants were controlled at 1 ppm in ponds having little or no flow-through. *Chara* sp. was controlled at 2 ppm in runoff ponds but was not controlled at 3 ppm in ponds having considerable water exchange at the time of treatment.

Water samples collected at various intervals from three ponds treated with simazine, diquat and fenac were tested for irrigation effects using corn, tomato and soybean plants. All samples collected from the simazine-treated pond up to four weeks, killed the tomato plants and damaged the soybean plants. Fenac-treated water stunted the growth of all plants up to four weeks. Diquat caused mottling of the test plants when the pond was sampled the same day and the day following treatment, but only caused a slight effect on growth after six days.

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I. INTRODUCTION

Excessive seasonal growths of submerged vascular plants and algae seriously inhibit the multiple utilitarian and recreational uses of Ontario farm ponds.

Every year the OWRC receives hundreds of requests for advice and assistance pertaining to the control of aquatic vegetation. To provide up-to-date information, the Commission conducts a continuing herbicide evaluation programme.

As a part of this programme, 37 farm ponds were treated with simazine (2-chloro-4,6-bis(ethylamino)-s-triazine), diquat (1,1-diethylene-2,3-dipyridilium dibromide) and fenac (2,3,6-trichlorophenylacetic acid) during the summers of 1966 and 1967 to determine the suitability of these compounds for controlling aquatic plants common to farm ponds in the southern portion of the province.

(Presented at the twenty-second annual meeting of the Northeastern Weed Control Conference, January 1968.)

II. METHODS AND MATERIALS

The 50% active wettable powder form of simazine and the liquid formulations of fenac (1.5 pounds active per gallon) and diquat (2 pounds active per gallon) were injected into the water from a motor boat by means of a simple boat bailer. Where the pond depth or density of vegetation precluded the use of an outboard motor, a back-pack sprayer was utilized. In one drawdown trial a 4% granular formulation of fenac was applied with a hand-operated rotary seeder.

With the exception of diquat which was applied on a gallonage-per-acre basis, all application rates for post-emergence treatments are expressed in parts per million by weight of the active ingredient. Rates for pre-emergence drawdown treatments are expressed in terms of pounds of active material per acre.

Pre- and post-treatment mud and water samples were collected to evaluate effects on bottom organisms and phyto-plankton.

III. DIQUAT TESTS

The results of using diquat in one runoff and six stream-fed ponds are illustrated in Table 1. In partial treatment plots at rates of one gallon and two gallons per acre, control of sago pondweed, Potamogeton pectinatus, was more immediate and permanent at the higher rate. Floating leaf pondweed, Potamogeton natans, appeared more resistant to diquat than the aforementioned species.

In total volume treatments, at two gallons per acre, seasonal control of P. pectinatus was obtained in one pond, regrowth after ten weeks occurred in another and control of short duration materialized in a pond containing extremely hard water (total hardness 224 ppm). In a runoff pond treated in August at a rate of two gallons per acre threadleaf pondweed, Potamogeton filiformis, was controlled for the balance of the season. Canada water weed, Anacharis canadensis, present in one trout pond, received only a temporary setback following a split application at the rate of one gallon per acre.

Stonewort, Chara sp. was unaffected in all treatments and no significant control of filamentous algae was achieved.

As noted in our previous tests in lake situations, the action of diquat was very spectacular, resulting in total elimination of the vegetation within a few days of

treatment. Reduction of the vegetation beyond the margins of the plot was noticed at the rate of two gallons per acre.

The effect of diquat on phytoplankton was studied in five ponds. No reduction was noted in two ponds in which diatoms dominated over flagellated algae and in two ponds in which blue-greens were co-dominant with flagellates. A substantial decrease (80%) occurred in one large pond where a diatom "bloom" prevailed when the diquat was applied.

TABLE 1. RESULTS OF USING DIQUAT FOR BOTH PARTIAL AND TOTAL VOLUME TREATMENTS IN 7 FARM PONDS

Pond or Plot	Rate	Date Applied	Vegetation Present	Results Achieved
1/4 acre plot	1 gal/acre	June 23	P.pectinatus... Chara sp.......	regrowth in 8 wks. no control
1/2 acre plot	1 gal/acre	June 24	P.pectinatus... Chara sp....... Spirogyra sp...	regrowth in 8 wks. no control no control
1/4 acre plot	1 gal/acre	June 21	P.pectinatus... P. natans......	regrowth in 6 wks. temporary reduction
1/4 acre plot	2 gal/acre	June 21	P.pectinatus...	seasonal control
Pond 1 runoff	2 gal/acre	Aug. 10	P.filiformis... Chara sp....... Mougeotia sp...	no regrowth no control temporary reduction
Pond 2 stream-fed	2 gal/acre	June 20	P.pectinatus... Chara sp....... Fontinalis sp.. Spirogyra sp...	regrowth in 6 wks. no control no control no control
Pond 3 stream-fed	2 gal/acre	June 20	P.pectinatus...	seasonal control
Pond 4 stream-fed	1 gal/acre	June 23 July 12	Anacharis canadensis... P.pectinatus... Chara sp.......	some regrowth in 4 wks. regrowth in 10 wks. no control

In agreement with Hilsenhoff's (2) findings, no direct toxic effects to bottom-dwelling organisms were indicated by quantitative dredge sampling before and after treatment.

To determine the rate of disappearance of diquat from the water, duplicate water samples were collected from three ponds. Methods used for the determinations of diquat residues were those described by Chipman Chemicals Limited.

Table 2 summarizes the results of the residue determinations.

TABLE 2. DIQUAT RESIDUES IN POND WATER (EXPRESSED IN PPM)

Pond Number	Rate of Application	Days after treatment 0	1	3	4	5	7
Pond I	2 gal/acre	0.30	N.D.*	-	-	N.D.	-
		0.26	0.006	-	-	N.D.	-
Pond II	2 gal/acre	1.04	0.49	-	0.21	-	-
		1.06	0.49	-	0.24	-	-
Pond III	1 gal/acre	0.15	0.10	0.014	-	-	N.D.
		-	0.04	0.020	-	-	N.D.

* N.D. - Non-detectable

IV. FENAC TESTS

Several workers including Pierce et al. (3), Gallagher et al. (1), and Whitley (5), have reported on the use of fenac as an aquatic herbicide. In Ontario, a preliminary study on the use of fenac as a post-emergence herbicide was initiated in 1966 and continued in 1967. Additionally, limited work was undertaken with fenac on a drawdown basis. The results of using fenac in total volume treatments are shown in Table 3.

Chara sp. was the dominant plant in the two runoff ponds treated in 1966, covering an estimated 80% of the bottom in each situation. Although 100% control of *Chara* sp. was achieved in both ponds, control materialized very slowly. Filamentous algae and duckweed, *Lemna minor*, were unaffected. Mid-summer inspections of these same ponds in 1967 revealed no regrowth of *Chara* sp.

TABLE 3. RESULTS OF TOTAL VOLUME TREATMENTS USING FENAC IN EIGHT FARM PONDS

Pond	Rate	Date Applied	Species Present	Results Achieved
Pond 1 (runoff)	3 ppm	June 8,'66	*Chara* sp. *Polygonum* sp. *Ranunculus* sp.	Browning after 3 wks.-elimination after 10 wks.
Pond 2 (runoff)	2 ppm	May 18,'66	*Chara* sp. *Ranunculus* sp. *Lemna minor* *Spirogyra* sp. *Mougeotia* sp.	Browning after 4 wks.-elimination after 12 wks. No control of duck-weed or algae
Pond 3 (stream-fed)	2 ppm	June 9,'66	*P.filiformis*	Elimination in 4 wks. Regrowth evident after 13 wks.
Pond 4 (runoff)	2 ppm	May 10,'67	*Chara* sp. *P.pectinatus* *Mougeotia* sp. *Cladophora* sp.	*P.pectinatus* eliminated after 8 wks. *Chara* sp. after 12. No control of algae.
Pond 5 (stream-fed)	2 ppm	June 9,'67	*Chara* sp.	No control
Pond 6 (stream-fed)	2 ppm	June 30,'67	*Chara* sp. *Drepanocladus* sp. *Lemna minor* *Spirogyra* sp. *Rhizoclonium* sp.	*Chara* browned after 5 wks.-eliminated after 10 wks. No control of other species.
Pond 7 (spring-fed)	1.5 ppm	June 9,'67	*Chara* sp. *Spirogyra* sp.	Browning only, followed by some regrowth after 11 wks. No control of algae.
Pond 8 (stream-fed	1 ppm	June 2,'67	*Chara* sp. *Anacharis canadensis* *Spirogyra* sp.	*Chara* similar to Pond 7. No control of other species.

Some emergent species were present in ponds 1, 2 and 3, (Table 4) treated in 1966. Marginal patches of sedge, *Carex* sp., and bulrush, *Scirpus* sp., were eliminated at 3 ppm but not at 2 ppm. Scattered peripheral growths of cattails, *Typha latifolia*, were controlled at 2 ppm and 3 ppm in the two runoff ponds but were unaffected at 2 ppm in the stream-fed pond.

Five additional ponds were treated with fenac in 1967 at rates of 1, 1.5 and 2 ppm. Abundant growths of *Chara* sp. were evident in all five ponds prior to treatment. Although complete browning of *Chara* sp. was observed in four ponds five to eight weeks after treatment, total elimination resulted in only two cases. In three ponds some regrowth of *Chara* sp. was evident by the end of August and early September, including one where total elimination had been achieved previously. At a rate of 2 ppm no control of *Chara* sp. was achieved in Pond 5, 0.06 acre-feet in size. Heavy rains caused the pond to increase in volume and flood over shortly after treatment.

Filamentous algae, moss (*Drepanocladus* sp.), *Lemna minor*, and *Anacharis canadensis* were not affected by fenac. *P.pectinatus* was controlled at 2 ppm.

All treatments in 1967 were undoubtedly influenced by an unusually heavy total rainfall over the summer period.

Two additional ponds were used for pre-emergence applications of fenac. A half-acre drawdown treatment at 15 lbs per acre, using both liquid and granular formulations, failed to provide control of *Chara* sp. and *P. pectinatus*. Filling of the pond after two days probably minimized the effectiveness of the treatment. In another drawdown trial 20 lbs per acre provided seasonal control of both species.

Seven ponds were sampled to study the effect of fenac on phytoplankton populations. Pretreatment phytoplankton levels were dominated by various combinations of diatoms, blue-green, green and flagellated types of algae, except in one pond where a "bloom" of *Cryptomonas* sp., a flagellated alga, was singularly dominant. No noticeable curtailment of phytoplankton was observed in three ponds following application of the herbicide. Although phytoplankton numbers dropped in three other ponds, total recovery was observed within six to ten weeks. In one pond where bloom conditions had been prevalent, phytoplankton numbers were reduced 75% and remained at this level for the balance of the season.

No gross reduction in bottom-dwelling organisms was indicated by quantitative dredge samples collected from three ponds prior to and following treatments.

Figure 1 - Pond in Albion Township
prior to treatment with
fenac - 1966

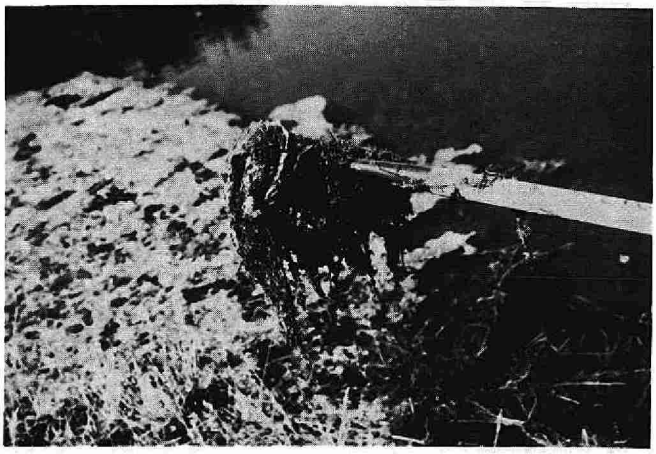

Figure 2 - Close-up of pond

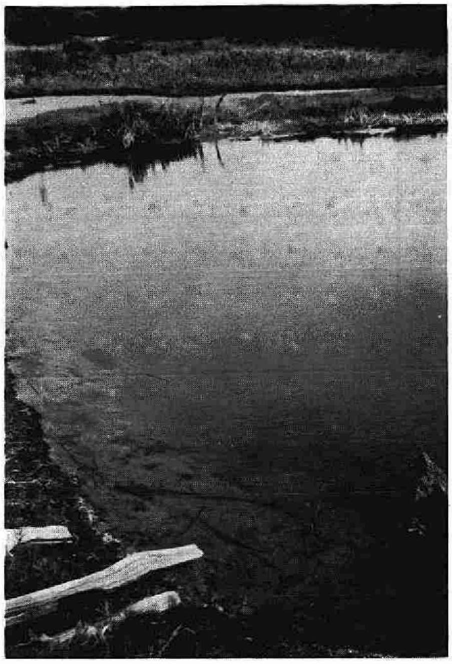

Figure 3 - Same pond three months after
treatment with fenac at a
rate of 2 ppm

V. SIMAZINE TESTS

Studies outlined previously by Schenk and Jarolimek (4) were continued in 1966 and 1967 to further establish the effectiveness of simazine against a variety of aquatic plants. Its efficacy in controlling Chara sp. was of particular interest, as was the suitability of a rate of 0.5 ppm for the control of filamentous algae.

Twenty treatments involving 17 ponds were made over the two-year period at rates from 0.5 to 3 ppm. The results are summarized in Table 4.

Applied at a rate of 0.5 ppm, simazine provided seasonal control of filamentous algae in three runoff ponds but regrowth was evident after six weeks in a stream-fed pond. P.pectinatus was controlled in one runoff pond at the minimal rate. At 1 ppm simazine was effective in controlling several species of submerged vascular plants and filamentous algae in ponds having little or no water exchange. Although lower rates were ineffective, growth of Chara sp. was retarded at 1.5 ppm and was controlled at 2 ppm. The inhibition of control owing to substantial water exchange is obvious even at 3 ppm.

TABLE 4. RESULTS OF 20 TREATMENTS WITH SIMAZINE IN 1966 AND 1967

Species	Rate ppm	Number of Ponds	Control E	G	F	P
Spirogyra sp.	0.5	3	3	-	-	-
	1	6	4	-	1*	1*
	2	2	2	-	-	-
	3	2	2	-	-	-
Cladophora sp.	0.5	1	1	-	-	-
	1	2	2	-	-	-
	2	1	1	-	-	-
Rhizoclonium sp.	0.5	1	1	-	-	-
	1	1	1	-	-	-
Mougeotia sp.	1	1	1	-	-	-
	1.5	1	1	-	-	-
	2	2	2	-	-	-
Chara sp.	0.5	1	-	-	-	1
	1	2	-	-	-	2*
	1.5	1	-	-	1	-
	2	2	2	-	-	-
	3	3	-	-	1*	2*
Lemna minor	1	2	2	-	-	-
	1.5	1	1	-	-	-
Potamogeton pectinatus	0.5	1	1	-	-	-
	1	4	2	-	-	2*
filiformis	1	1	1	-	-	-
	2	1	1	-	-	-
crispus	1	2	2	-	-	-
Anacharis canadensis	1	1	1	-	-	-
Polygonum sp.	1	1	1	-	-	-
Drapanocladus	1	1	1	-	-	-
Ranunculus sp.	2	1	1	-	-	-
Eleocharis sp.	1	1	1	-	-	-

*Substantial water exchange at time of treatment

E - excellent; G - good; F - fair; P - poor

In general reduction of the vegetation was usually evident seven to fourteen days following treatment with simazine. Chara sp. was more resistant to simazine than the pondweeds and filamentous algae. As demonstrated by earlier tests, the rate of water exchange in the pond at and following the time of treatment is a critical factor.

A three-year programme involving annual applications of simazine was initiated in 1965 to determine the permanency of control achieved following cessation of the repetitive treatments. One stream-fed and two runoff ponds were included in this study.

In the stream-fed pond, initial control of P. pectinatus and filamentous algae was achieved with 1.5 ppm simazine in 1965 but a rate of 1 ppm failed to provide control in 1966 and 1967.

One runoff pond was treated at 1 ppm each year. Control of P.pectinatus in 1965 was followed by regrowth of Chara sp. after ten weeks. In 1966, A.canadensis and P. crispus developed, which were succeeded by Drepanocladus sp. and spike rush, Eleocharis sp. eleven weeks after treatment. The latter two species developed again in 1967 and were controlled for eleven weeks.

In the remaining runoff pond, Chara sp., P.crispus and filamentous algae were controlled for the entire 1965 season at 2 ppm. A rate of 1 ppm controlled scattered growth

of _P_._pectinatus_ and some filamentous algae the following year. Prior to treatment in 1967, only filamentous algae were present in the pond and were readily controlled with 1 ppm simazine for the balance of the season.

VI. USE OF TREATED PONDS FOR IRRIGATION PURPOSES

Water samples collected at various intervals (Table 5) from three ponds treated with simazine, fenac and diquat were tested for the presence of herbicides using corn, soybean and tomato plants.

TABLE 5. WATER SAMPLE COLLECTION FOLLOWING TREATMENT

Herbicide	Rate	Interval after treatment (days)						
		0	1	2	6	7	21	28
simazine	3 ppm		x	x		x	x	x
fenac	2 ppm		x	x		x	x	x
diquat	1 ppm	x	x		x			

Paper cups containing test plants were watered daily for two weeks with 50 ml of the pond water. Duplicate tests were performed with solutions of the herbicides prepared in the laboratory.

Tomato plants were killed and soybean plants damaged by all water samples collected from the simazine-treated pond. Fenac stunted the growth of all plants, although plants watered with a sample collected three weeks after treatment were less severely stunted than those exposed to water sampled after two weeks. Figure 4 illustrates the effect on tomato plants watered with samples collected from two ponds one day after treatment with simazine (3 ppm) and fenac (2 ppm). Diquat-treated water caused mottling of all

test plants when the pond was sampled the same day and the day following treatment. The sample taken one week after treatment had no chlorotic effect but did seem to slightly decrease the growth of the test plants.

Figure 4 - Effect of simazine and fenac treated pond water on tomato plants

VII. ACKNOWLEDGEMENTS

Appreciation is extended to Chipman Chemicals Ltd., Fisons (Canada) Ltd., and Amchem Products, Inc., for providing the herbicides. Data on the effects of herbicide-treated water on various test plants were kindly provided by Dr. C. M. Switzer of the University of Guelph.

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